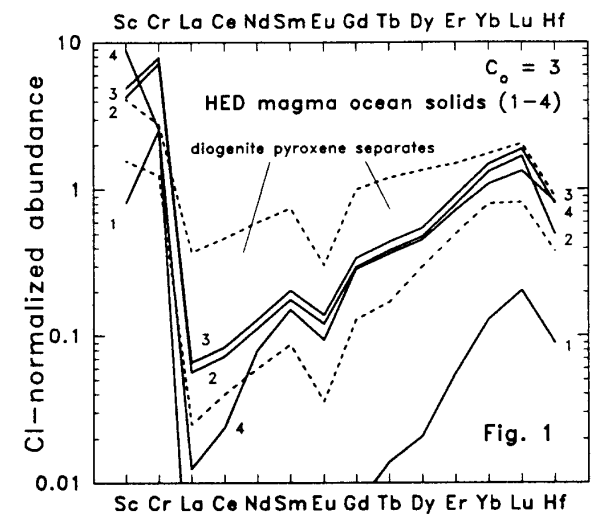


FORMATION OF EUCRITES AND DIOGENITES IN A MAGMA OCEAN ON THE HED PARENT BODY. Alex Ruzicka, Gregory A. Snyder, and Lawrence A. Taylor. Planetary Geosciences Institute, Dept. Geological Sciences, University of Tennessee, Knoxville, TN, 37996.

Based on a comparison of major- and trace-element data for diogenites and eucrites with the predictions of a geochemical model, it appears that: (1) diogenites could be orthopyroxene cumulates produced by fractional crystallization in a magma ocean on the HED (howardite-eucrite-diogenite) parent body; and that (2) Main Group non-cumulate eucrites could be the residual liquids produced in the same magma ocean.

ASSUMPTIONS AND APPROACH-- We assume that: (a) diogenites and eucrites formed in the same parent body, with the composition of the silicate portion identical to that given by Dreibus and Wänke [1]; and (b) the parent body was entirely (or at least extensively) molten. The program MAGFOX, developed by J. Longhi, was used to determine the crystallization sequence, mineralogy, and major-element composition of cumulates and residual liquids produced by fractional crystallization in an HED magma ocean [2]. The first four crystallization products in the magma ocean are as follows: (1) olivine (Fo_{92-82} ; 0-56% solidification of the magma ocean); (2) orthopyroxene ($\text{En}_{84-80}\text{Wo}_{0.8-1.1}$; 56-62% solidification); (3) 95 vol% orthopyroxene ($\text{En}_{80-74}\text{Wo}_{1.1-2.2}$) + 5% chromite (62-69% solidification); (4) pigeonite ($\text{En}_{74-56}\text{Wo}_{2.0-4.3}$; 69-78% solidification). Subsequent fractional crystallization would involve the formation of plagioclase, increasingly ferrous and calcic clinopyroxene, ferrous olivine, and silica polymorph. The results for magma ocean crystallization were combined with estimates [3-4] of mineral/melt partition coefficients for a variety of trace and minor elements to determine the abundance of trace and minor elements in cogenetic cumulates and residual melt.

RESULTS-- The predicted major-element compositions for orthopyroxene in assemblages (2) and (3) are similar to, but slightly more magnesian and more varied than, that observed for orthopyroxene in diogenites (range En_{79-66} , mainly En_{74}) [5-6]. The relatively restricted range in major element composition for orthopyroxene in diogenites contrasts with the large range in minor- and trace-element abundances observed for this pyroxene [5-6]. This may indicate that diogenites initially formed as cumulates over an extensive crystallization interval, and that they experienced extensive subsolidus re-equilibration that primarily affected major elements [5-6]. The predicted modal mineralogy (>90 vol% orthopyroxene) resembles that of diogenites [7], but the model underestimates the amount of olivine and overestimates the amount of chromite. The underestimate of olivine abundance is possibly indicative of partial entrapment of settling olivine grains in the orthopyroxenite cumulate pile. The discrepancy in chromite abundance may indicate that MAGFOX overestimates the amount of early-crystallizing chromite that will be produced for this melt composition. Predicted abundances of highly incompatible trace elements are consistent with observations for diogenites, assuming that the initial CI-normalized abundance of refractory elements (C_0) in the parent body was ~ 3 (Fig. 1; diogenite data: [5], CI data: [9]). Thus, it appears that *diogenites could have formed as cumulates in a magmatic system with the major-element composition of the HED*

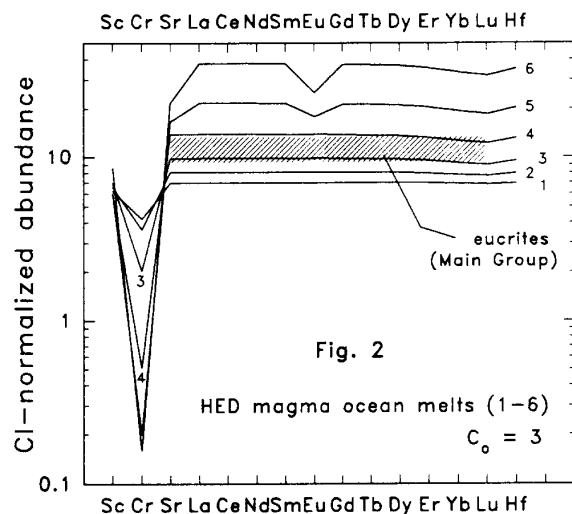


parent asteroid given by [1], provided that the parent body was enriched in refractory elements by $\sim 3 \times \text{CI}$. The major-element composition of eucrites is generally similar to that of model liquids produced after 69-78% magma ocean solidification (melts 3 and 4; Table 1). These residual melts are produced after the crystallization of orthopyroxene, and before the crystallization of plagioclase. The principal discrepancy is that the model liquids have less Cr

Table 1. Major-element composition of eucrites compared with model residual melts produced after 69% (melt 3) and 78% (melt 4) solidification of an HED magma ocean with the initial composition of Dreibus and Wänke [1], based on the MAGFOX program.

		melt	melt
eucrites*		3	4
wt%			
SiO ₂	48.07-49.46	50.99	49.66
TiO ₂	0.56-1.09	0.39	0.54
Al ₂ O ₃	10.35-13.00	8.45	11.74
Cr ₂ O ₃	0.28-0.44	0.08	0.07
FeO	17.92-20.10	21.42	22.46
MgO	5.46-8.37	10.73	5.13
MnO	0.50-0.59	0.79	0.83
CaO	9.48-10.58	6.80	9.07
K ₂ O	0.03-0.08	0.03	0.04
Na ₂ O	0.45-0.57	0.31	0.44
at%			
Mg/(Mg+Fe)	35-47	47	29

* Non-cumulate eucrites: [10].



than observed for eucrites (Table 1). In the model, Cr is low in residual liquids mainly because Cr is sequestered in early-crystallizing chromite. This discrepancy can be explained if the MAGFOX program overestimates the amount of chromite that co-crystallizes with orthopyroxene, as noted above. Model melts 3 and 4 also have CI-normalized abun-

dances of incompatible-trace elements that bracket those observed for Main Group (non-cumulate) eucrites, assuming that $C_o \sim 2.5-3$ (Fig. 2; Main Group eucrite data from [10], renormalized to the CI abundances of [9]). Thus, the data suggest that *Main Group eucrites could have formed as residual melts in a magmatic system with the major-element composition of the HED parent asteroid given by [1], provided that the parent body was enriched in refractory elements by $\sim 2.5-3 \times CI$. As the same system can account for diogenites, it appears that eucrites and diogenites could have formed from the same, chemically evolving magmatic system. These results support the idea that HED meteorites were derived from a magma ocean on the HED parent body [8].*

References: [1] Dreibus G. and Wänke H. (1980) Z. Naturforsch. 35a, 204-216. [2] Ruzicka A. et al. (1996) In Workshop on Evolution of Igneous Asteroids, LPI Tech. Report No. 96-02, pp. 23-24. [3] Snyder G.A. et al. (1995) GCA 59, 1185-1203. [4] Ruzicka A. et al. (1997) Could eucrites have formed as residual liquids in a magma ocean? This volume. [5] Mittlefehldt D. (1994) GCA 58, 1537-1552. [6] Fowler G.W. et al. (1994) GCA 58, 3921-3929. [7] Bowman L.E., Papike J.J. and Spilde N.N. (1996) LPS XXVII, 147-148. [8] Ikeda Y. and Takeda H. (1985) PLPSC 15th, C649-C663. [9] Anders E. and Grevesse N. (1989) GCA 53, 197-214. [10] BVSP (1981) Basaltic Volcanism on the Terrestrial Planets, 1286 pp.